



Human Space Flight Architecture Team (HAT) Overview

Chris Culbert

NASA/Johnson Space Center

GER Workshop, November 2011



Exploration Capability Development and Testing

NASA Policy

Authorization Act
Strategic Goals
Budget

HSF Architecture Team

Architectures • Elements •
Trade Studies • Technology &
Capability Requirements

Cross-Directorate Capability Integration

- Exploration Technology Testing & Demonstration Strategy
- Analogs Objectives
- ISTAR

Opportunity
Development

Partnerships

- Global Exploration Roadmap
- NASA/partner DRMs
- Academia
- Element development

Exploration
Capabilitites
Requirements

HEO Orgs

- ESD
- AES
 - analogs
 - robotic precursors
- SLPSR

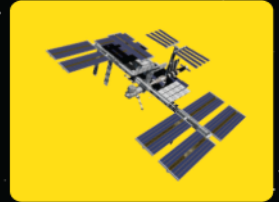
Other NASA Orgs

- OCT
- SMD
- OCE

External Partners

- International
- OGAs
- Commercial

ISS Utilization



NASA Centers



Call for Technology
Proposals

Mature Exploration Capabilities

- Communications
- Deep-space habitation
- Extravehicular Activity
- In-space propulsion
- Heavy lift
- Launch propulsion
- Robotic systems

Strategic Integration
Implementation

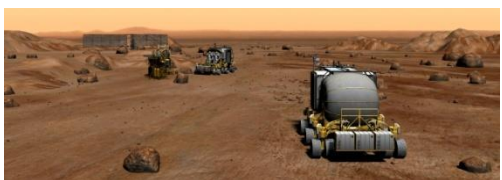
NASA's Human Spaceflight Architecture Team (HAT)

- ◆ **Multi-disciplinary, cross-agency study team that conducts strategic analysis cycles to assess integrated development approaches for architectures, systems, mission scenarios, and concepts of operation for human and robotic space exploration.**
 - During each analysis cycle, HAT iterates and refines design reference mission (DRM) definitions to inform integrated, capability-driven approaches for systems planning within a multi-destination framework.
- ◆ **Sample Activities in 2011 – Cycles A, B, C**
 - Prepared Design Reference Missions that frame key driving requirements for SLS & MPCV
 - Developed technical content & mission definitions for discussion with the international community developing the Global Exploration Roadmap
 - Advanced Capability Driven Framework concept including more extended reviews of both capabilities needed and development options.
 - Provided technical links between Capability Driven Framework and level 1 requirements for MPCV and SLS

Primary Transportation DRMs

Select destinations used to drive transportation systems requirements and assess impacts of changes in mission assumptions

Proposed Status	ISECG	DRM ID	DRM Title	Dest.
Cycle-C	N	LEO_UTL_2A	LEO Utilization - Non-ISS	LEO
Cycle-C	Y	CIS_LP1_1A	Lunar Vicinity - EM L-1	E-M L1
Cycle-C	Y	CIS_LP1_1B	Lunar Vicinity - EM L-1 DSH Delivery	E-M L1
Cycle-C	Y	CIS_LP1_1C	Lunar Vicinity - EM L-1 with Pre-deployed DSH	E-M L1
Cycle-C	Y	CIS_LLO_1A	Low Lunar Orbit	LLO
Cycle-C	Y	LUN_SOR_1A	Lunar Surface Polar Access - LOR/LOR	Moon
Cycle-C	Y	LUN_CRG_1A	Lunar Surface Cargo Mission	Moon
Cycle-C	N	NEA_MIN_1A	Minimum Capability, Low Energy NEA	NEA
Cycle-C	Y	NEA_MIN_1B	Minimum Capability, Low Energy NEA with Pre-deployed DSH	NEA
Cycle-C	N	NEA_MIN_2A	Minimum Capability, High Energy NEA	NEA
Cycle-C	N	NEA_FUL_1A	Full Capability, High Energy NEA with SEP	NEA
Cycle-C	Y	NEA_FUL_1B	Full Capability, High Energy NEA with SEP and pre-deployed DSH	NEA
Forward Work	N	MAR_PHD_1A	Martian Moon: Phobos/Deimos	Mars Moon
Forward Work	N	MAR_SFC_1A	Mars Landing	Mars Surface



Evolution of Key Assumptions that Drive Transportation System Performance

HEFT

◆ 10% Architecture Reserve

- on wet cargo stack (+ adapter) mass

◆ 2.5% launch vehicle adapter mass

- on wet cargo stack mass

◆ 1% Flight Performance Reserve (FPR) on ΔVs

◆ Elements Margins

- MPCV: data provided
- Other elements: 30% MGA

◆ Insertion orbit:

- 55.56 x 240.76 km

◆ Crew of 3 on Lunar & NEA missions

◆ 25 meter SLS shroud barrel

Cycle-A

◆ 5% Level I Customer Reserve

- on wet cargo stack (+ adapter) mass

◆ 2.5% launch vehicle adapter mass

- on wet cargo stack mass

◆ 5% Flight Performance Reserve (FPR) on ΔVs

◆ Elements Margins

- MPCV: data provided
- CPS BLK1: 15%
- Other elements: 30% MGA

◆ Insertion orbit:

- 55.56 x 240.76 km

◆ Crew of 3 on Lunar & NEA missions

◆ 25 meter SLS shroud barrel

Cycle-B

◆ 5% Level I Customer Reserve

- on wet cargo stack (+ adapter) mass

◆ 2.5% launch vehicle adapter mass

- on wet cargo stack mass

◆ 5% Flight Performance Reserve (FPR) on ΔVs

◆ Elements Margins (Derived from AIAA Standards)

- MPCV: data provided
- Other elements: 30% MGA

◆ Insertion orbit:

- -87 km X 241 km

◆ Crew of 4 on Lunar & NEA missions

◆ 18 meter SLS shroud barrel

Cycle-C

◆ 5% Level I Customer Reserve

- on wet cargo stack (+ adapter) mass

◆ 2.5% launch vehicle adapter mass

- on wet cargo stack mass

◆ 5% Flight Performance Reserve (FPR) on ΔVs

- Except for MPCV burns

◆ Elements Margins (Derived from AIAA Standards)

- MPCV : data provided
- CPS: BLK1 - 18.8%, BLK 2- 21.2%
- Lander: Margin remains on lunar surface
- Other elements: 30% MGA

◆ Insertion orbit:

- -87 km X 241 km

◆ Crew of 4 on Lunar & NEA missions

◆ 18 meter SLS shroud barrel

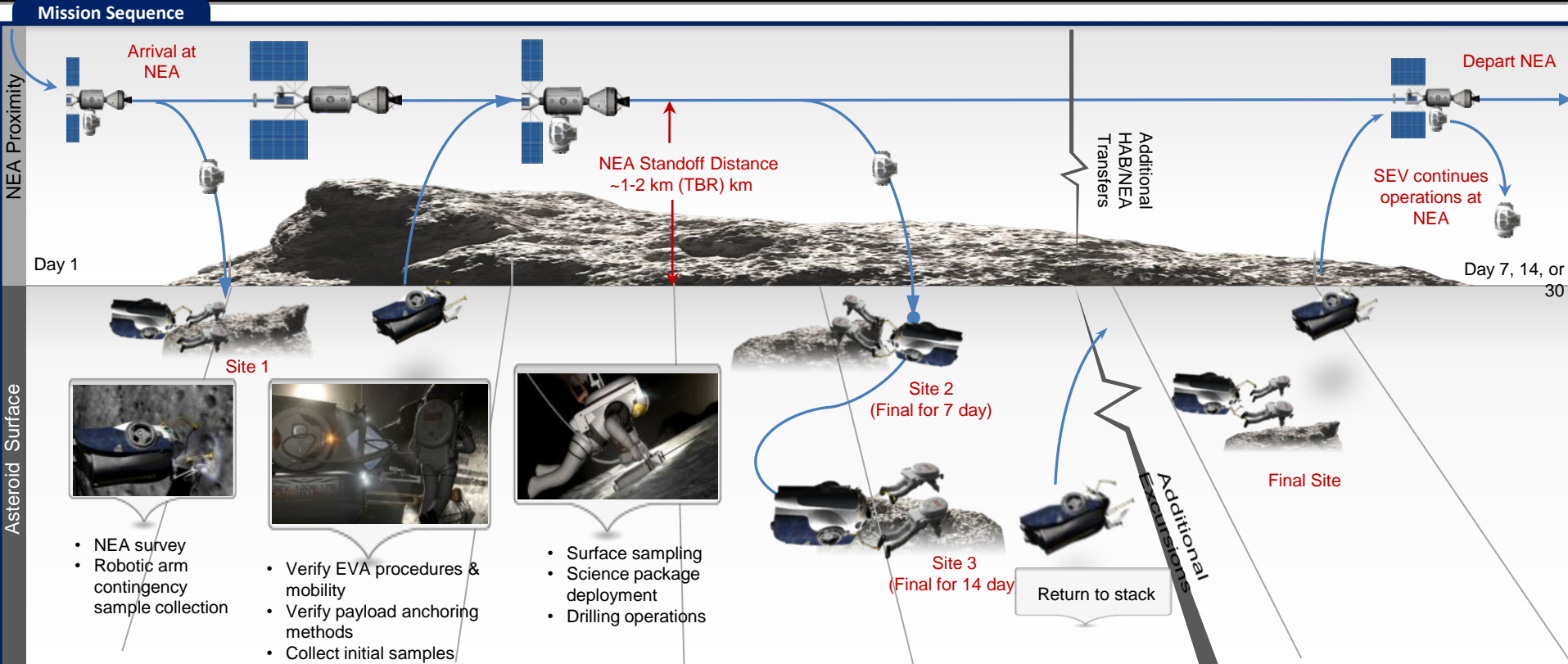
NEA_FUL_1A_C11B1

30 d at NEA

- SEV
continues
Operations
at NEA



NEA Exploration - Single SEV Option; 7, 14 or 30 days at NEA



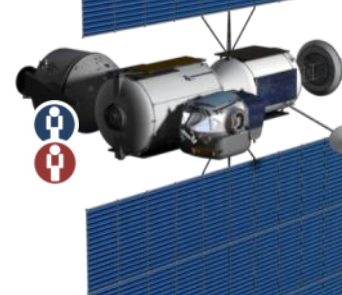
Mission Summary

package deployment

SEV robotic arms anchor to the NEA surface and provide astronaut platforms during EVA. The mother-ship stack, including the SEP, DSH, and MPCV, stationkeeps at a safe standoff distance. Surface activities include sample collection and deployment of probes (radar, acoustic, seismometer, etc.), experiments and planetary defense devices.

Mission Activities	7 Day	14 Day	30 Day
Number of deployed equipment packages	4	10	24
Total EVA hours	48	96	192
Number of sites visited	2	3	6
Total Est. Mass (kg) delivered/returned	tbd/tbd	tbd/tbd	tbd/tbd

Mission Site: Near Earth Asteroid



Crew: 4

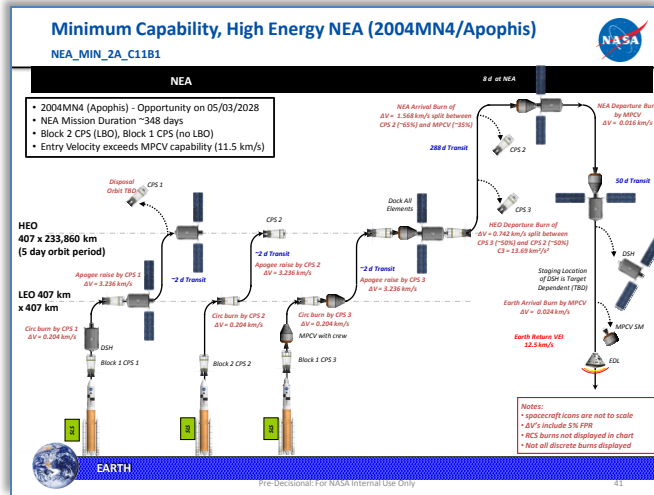


HAT Cycle C Updates

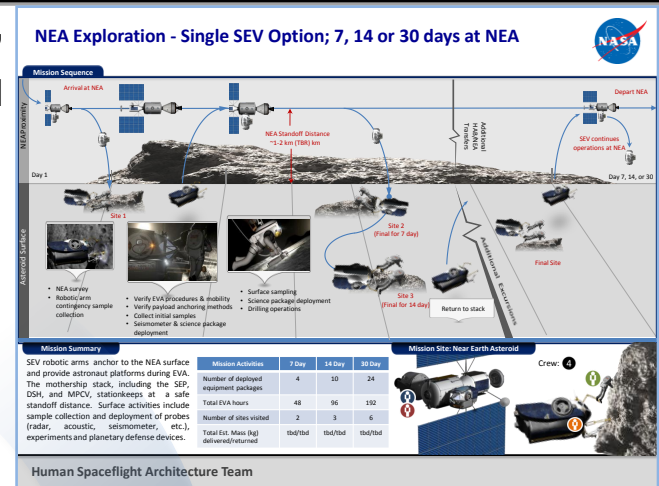
◆ Cycle C work by the HAT team continued to refine the DRMs to improve both consistency and technical feasibility. Some key changes:

- Direct injection to destination when possible
 - Removed circularization burn to 407 km x 407 km where applicable
- Clarified boil-off requirements and identified usable propellant and dry mass of propellant units separately
- Continued to add depth to the definition of human activities while at destinations
- Developed and utilized consistent operational timeline assumptions
 - See back-up for assumptions
- Improved consistency of margin analysis for many elements and phases, such as MPCV propulsive burns
- Resolved station keeping problems
 - Deep Space Hab always attached to another element for ACS/RCS
- Shifted DRMs between primary and supporting, added new DRMs to primary
 - To improve alignment with programmatic activities in preparation for on-going SRR

Destination Products

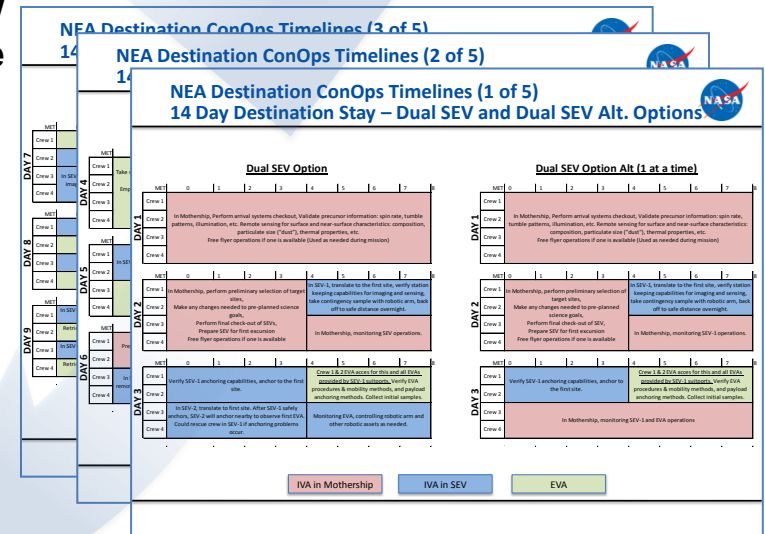
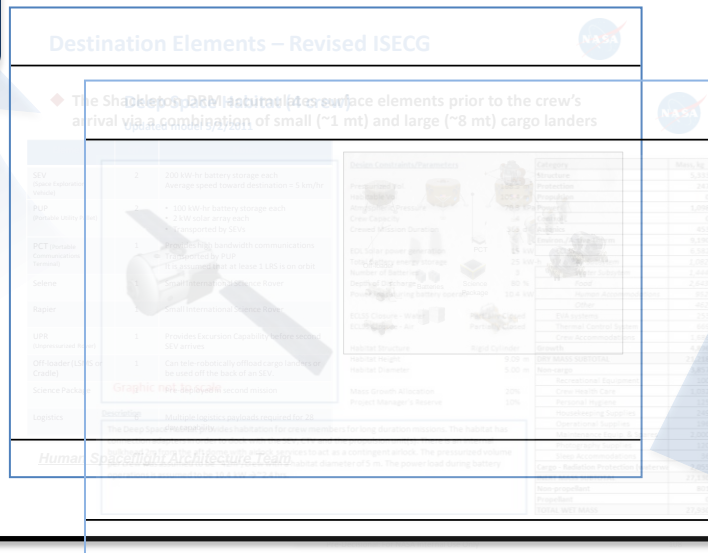


“Street View” Destination DRM



Feedback to Transportation DRMs

Ops Con/ Ops Timeline

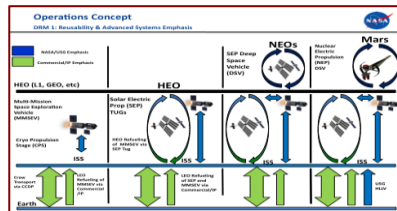


Destination Elements “Baseball Cards”

Informing Exploration: Strategic Knowledge Gaps

- ◆ **To inform mission/system planning and design *and* near-term Agency investments**
 - Human Spaceflight Architecture Team (HAT) Destination Leads were asked to identify the data or information needed that would reduce risk, increase effectiveness, and aid in planning and design
 - The data can be obtained on Earth, in space, by analog, experimentation, or direct measurement
 - ◆ **For some destinations, the needed knowledge is well identified**
 - Analysis Groups, such as LEAG and MEPAG, have identified pertinent measurements to gain the needed knowledge regarding the Moon and Mars
 - Significant advances in filling the knowledge gaps have been made (examples: LRO and MRO, and soon, MSL)
 - ◆ **The Strategic Knowledge Gaps (SKGs) identified here represent an informed and systematic look at anticipated needs**
 - Inputs and comments from other agencies are welcome in order to provide for an international discussion during the January ISECG Workshop
 - ◆ **The SKGs will also form the basis for near-term NASA investments in robotic precursor missions through Announcements of Opportunity (AO), competed and secondary missions, etc. A few examples include:**
 - New Frontiers 4 AO
 - Discovery 13 AO
 - NASA Lunar Science Institute Cooperative Agreement Notice
 - LASER (Lunar Advanced Science and Exploration Research) and SALMON (Stand Alone Missions of Opportunity Notice) calls
 - Development of early flight opportunities
-

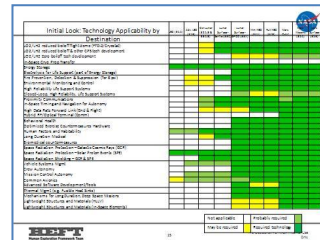
Architecture Cost Analysis Approach



Technical Design Reference



Investment strategy

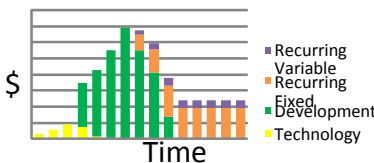


Technology Assessment

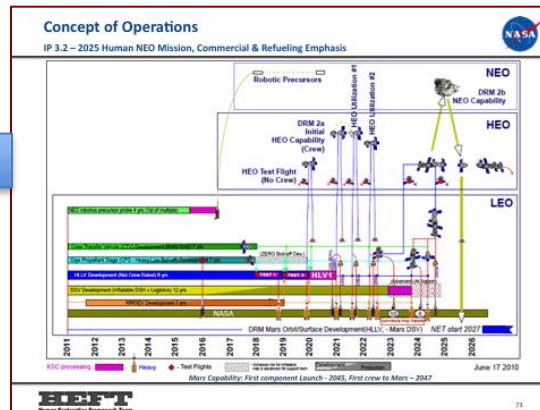
Capabilities Catalogue In-Space Crew Elements		
Capability	Description	Required Technology
MMSEV	The MMSEV is configured as a destination/destination system. The MMSEV design provides structural volume and logistics to support, for example, the MMSEV provides primary habitation and technology for a multitude of in-space missions and serves as an enabler for deep space exploration. It has the capability to support EVAs through two subjects and is a crew-controlled grapple system for sample collection and retrieval and to access their samples without EVA.	<ul style="list-style-type: none"> • RCS (GNC/DSO) • EVA (Support, suits, etc) • Radiation Protection • Solar Power: 20%
DSH	The DSH provides habitation for crew members while in transit to and from NEOs. The habitat has connection adapters in order to dock with the MMSEV and the propulsion unit. The MMSEV will supply the main EVA operations for the DSH.	<ul style="list-style-type: none"> • Inflatable structures • Power system • Avionics & software • Thermal solutions • Advanced medical care • Biomedical counter-measures • Environmental monitoring & control • Closed loop ECLSS (95-98% air and water) • Fire prevention, detection, & suppression • Radiation protection
LM	Similar to an ISS MPLM. Provides storage for DSH.	

Element catalog

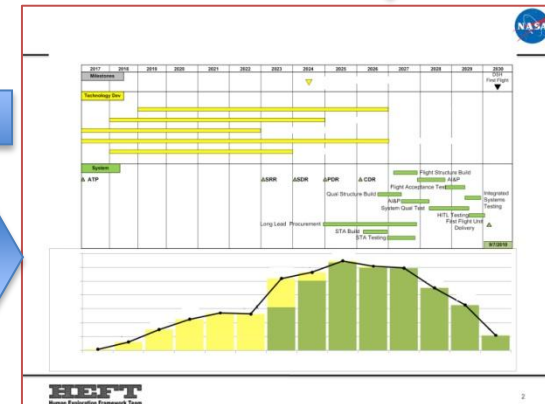
Element Fixed/Variable Sandbar Chart



Cost Products

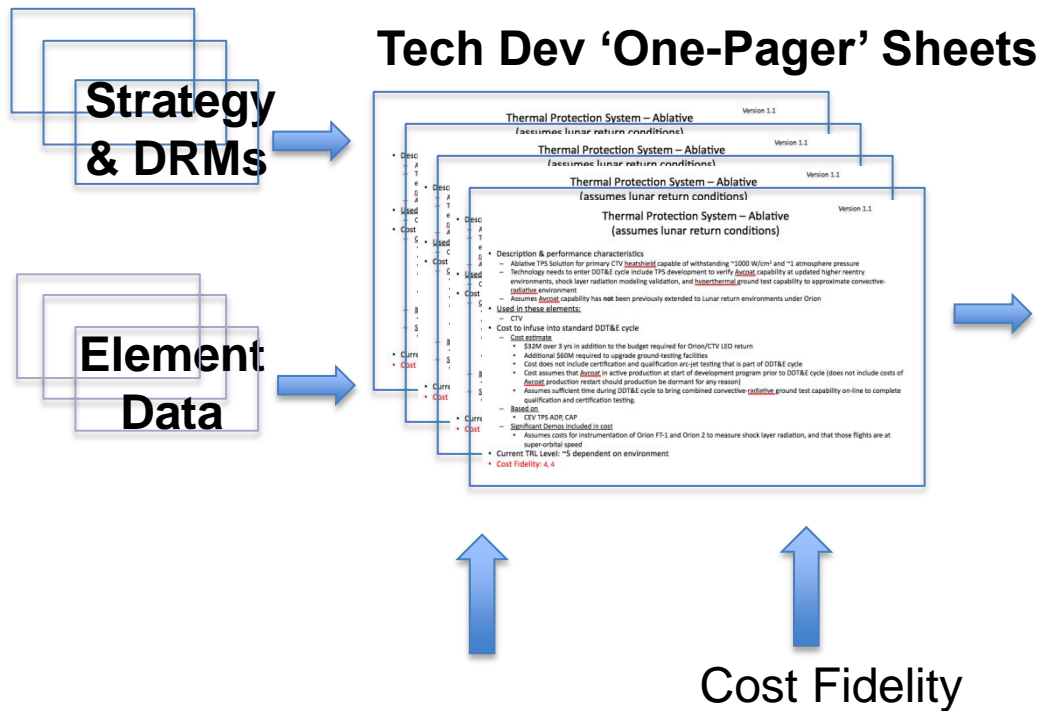


Integrated program schedule & flight manifest



Schedule and cost to develop and operate each element

Technology Development Assessment: Data Capture Process



'Tech Dev' Summary Spreadsheet (per Strategy/DRM)

Initial Look: Technology Applicability by Destination

Destination	AE (1.1)	AE (1.2)	AE (1.3)	AE (1.4)	AE (1.5)	AE (1.6)	AE (1.7)	AE (1.8)	AE (1.9)	AE (1.10)	AE (1.11)	AE (1.12)
AE (1.1)												
AE (1.2)												
AE (1.3)												
AE (1.4)												
AE (1.5)												
AE (1.6)												
AE (1.7)												
AE (1.8)												
AE (1.9)												
AE (1.10)												
AE (1.11)												
AE (1.12)												

Legend: Not applicable (white), Probably required (yellow), May be required (light green), Required technology (dark green), Not used (red).

- Tech Dev Data for HAT Cost Team:
 - Cost, Schedule, Phasing
 - Applicable Elements (per DRM)
- ETDD/OCT/HRP Data Inputs
- HEDS Data Inputs (e.g. AES priorities, Analogs, ISS demo candidates, etc.)
- ISECG Technology Dev Inputs

Subject Matter Expert POCs
(e.g. ETDD/OCT, HRP, Element Leads, SE, etc.)

Cost Fidelity Matrix

How well do we know this problem?	Very poorly	Little or no plan	How well defined is the plan?	Full, multi-year project plan
5	1	2	3	4
4	2	3	4	5
3	3	4	5	6
2	4	5	6	7
1	5	6	7	8

Legend: High Fidelity (green), Medium Fidelity (yellow), Low Fidelity (red).